The Role of House Dust in Human DDT Pollution

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A study of pesticide residues in house dust indicates that contamination of house dust by domestic use of DDT and other pesticides is primarily responsible for human serum residues.

Introduction

In warmer climates, the various pests and insects present a very special domestic problem resulting in wide differences in the amount, frequency, and types of pesticides applied in the home. Elsewhere we have suggested that differences in domestic pest control practices might be an important mechanism in the occurrence of higher levels of organochlorine pesticides in the serum of the poor than in the more affluent.[1] House dust is contaminated by these domestic applications and in semitropical climates, pesticide residues in dust are probably just as important in contributing to incidental human exposure as are food sources.[1-4]

Through the cooperation of the Ministry of Health in the Bahamas, the Departments of Family Medicine and Epidemiology and Public Health, University of Miami School of Medicine, and the Florida State Division of Health, it was possible to test this hypothesis during a health and ecology survey being conducted in a small island in the Caribbean. The island, which is one of a chain of islands situated on the east side of the Gulf Stream and facing the Florida coastline, is approximately 7 miles long and 200 to 400 yards wide. The area is unsuitable for agriculture and horticultural development and the 1500 inhabitants, most of whom are blacks, rely on fishing and tourism for their livelihood. Since the area had not been aerially sprayed with DDT, the ecological situation of the island provided an ideal opportunity to measure pesticide concentrations in the food, air, water, soil, and house dust, and to relate these to the serum prevalences of the islanders. This paper reviews these findings and, in particular, assesses the role of the domestic use of DDT in human pesticide pollution in this tropical setting.

TABLE 1—Demographic Distribution of 254 Samples of the Island Study Group Analyzed for Pesticides by Age, Race, and Sex, 1970–1971

Age Groups	Black		White	Total
	Males	Females	(Males)	
0–19	51	51		102
20+	39	109	4	152
Total	90	160	4	254

Materials and Methods

Medical personnel from the Division of Family Medicine and from the Ministry of Health in the Bahamas

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TABLE 2—Serum DDT, DDE, and Total DDT (ppb) Residues in the Island Population 20 Years and Over

Group	No.	DDT		DDE		Total DDT		Dieldrin	
		$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range
Black males	39	27	4–94	81	9–238	117	15–451	1.3	0.5–5.7
Black females	109	36	7–178	61	13–298	106	24–527	1.1	0–9.2
p value*		0.05		NSD†		NSD		NSD	

* Two sample *t*-test (males versus females).
† No significant difference at 0.05 level.

conducted a health and ecology survey on 530 members of the island community. In addition to visual screening, immunizations, and cytologies, physical examinations were performed which included the collection of a blood sample for SMA-12 studies. Organochlorine studies were conducted on 254 islanders attending the health fair. Eight milliliters of blood were collected in 10-ml B.D. Vacutainer tubes from the study group. After clotting, the blood was centrifuged and the serum was separated and stored at 4° C. In addition, information on the frequency and type of pesticide used in each home was obtained by questionnaire. Persons with any history suggestive or recent or remote pesticide occupational exposure were excluded from the study and a survey of the local stores was conducted with the purpose of obtaining information on the types of pesticides sold for domestic use.

Items of food reflective of a typical native diet were analyzed for pesticide residues. Similarly, several analyses were made of water. These were collected in sterile hexane-washed jars and were obtained from three sources in the island: wells, a cistern, and the desalinization plant. Air samples were collected from two M.R.I. air samplers; one was located in the island and one was in Dade County. These were run simultaneously over a 24-hr period and information on the wind direction and velocity, the high-low temperatures, and relative humidity in each site was noted. Paired dust and soil samples were collected from 15 homes. The soil, which was sandy, was collected from the surface on the four sides of the house and down to a depth of 1 inch. Ten to 20 gm of dust were swept from the floor with a broom into a dust pan and then transferred into a hexane-washed aluminum bag. A separate broom and pan was used for each home. The dust and soil samples were then sieved through a standard 230 seive which permitted analysis to particle sizes of 63 μ. Specimens were analyzed for organochlorine residues by electron capture gas chromatography. A modification of the Dale, Curley, and Cueto method for organochlorine analysis in serum was used.[5] The modification involved the use of a rotary shaker which rotated the mixture for a period of 2 hr. The lower limits of sensitivity for this modified method were 1 ppb for *p,p'*-DDE, B-BHC, heptachlor epoxide, and dieldrin, and 2 ppb for *o,p'*-DDT, *p,p'*-DDD (TDE), respectively. Only *p,p'*-DDT and its metabolites* and dieldrin are discussed in this report.

* All references to DDT and DDE are to the *p,p'*-isomers. DDT: 2,2-bis(*p*-chlorophenyl)1,1,1-trichloroethane; DDE: 2,2-bis(*p*-chlorophenyl)1,1,-dichloroethylene.

TABLE 3—Comparison of Serum DDT, DDE, Total DDT, and Dieldrin (ppb) of the Island Population with the Dade County, FL, General Population, Adult Blacks, Social Classes IV and V, 1970–1971

Pesticides	Islanders (n = 148)		Dade County Gen. Pop. (n = 164)	
	$\bar{x}$	Range	$\bar{x}$	Range
DDT	34	4–177	10	0–53
DDE	66	9–328	47	4–180
Total DDT	109	15–527	63	6–230
Dieldrin	1.1	0–9	1.1	0–5
Age	39		43.2	

The analytical methods for pesticide residues in air, water, soil, and house dust were the standard procedures recommended by the *Manual of Analytical Methods* issued by the Perrine Primate Research Laboratory of the Environmental Protection Agency, Perrine, Florida.[6] Several analytical procedures were used for food residues; fatty and nonfatty foods were analyzed by the method of Mills et al. and eggs by the Sawyer method. Procedures are described in the Food and Drug Administration's *Pesticide Analytical Manual.*[7]

Results

Table 1 lists the age, race, and sex composition of the 254 residents of the island on whom organochlorine serum prevalences were obtained; 250 were black and four were white. Table 2 presents the mean and ranges of serum organochlorine residues from 148 adult black islanders. The four white males were omitted because of the smallness of numbers. Since significant age effects on Serum DDT residues had been noted in a general population survey in Dade County, the islanders under 20 years of age were excluded. There were no significant differences between males and females except for DDT residues, which were significantly higher in females than in males, a finding which supported a domestic exposure, since the women of the island spend more of their time in the home than do the

TABLE 4—Pesticide Residues (ppm) in Typical Foods Consumed by the Island Study Group, 1970–1971

Food	*p,p*-DDT	*p,p*-DDE	*p,p*-DDD	*o,p*-DDT	Dieldrin
Snapper fish	0.01	0.01	0.01	–	<0.004
Conch 1	0.4	–	–	–	0.1
Conch 2	0.6	–	–	–	0.5
Native bread	0.032	0.06	–	0.01	0.05
Bahamian bread	–	–	–	–	–
Native eggs	0.005	0.007	0.007	0.001	0.002
Native bananas	–	–	–	–	–
Native cabbage	–	–	–	–	–
Black eye peas (canned)	–	–	–	–	–
Pigeon peas (canned)	<0.01	<0.004	0.02	–	–
Cut okra (canned)	<0.01	<0.004	<0.01	–	–
Pork chops	<0.01	<0.004	–	–	<0.004
Chicken	<0.01	<0.004	–	–	<0.004
Steak	<0.01	<0.004	–	–	–
Milk	0.05	0.10	<0.02	<0.02	0.03
Green pigeon peas (canned)	–	–	–	–	–

TABLE 5—Pesticide Residues (ppt) in Water from Three Sources in the Island, 1970–1971

Source	Date Collected	DDT	Dieldrin	Lindane
Well water	1/71	–	10	–
Desalinized plant	1/71	–	2.6	–
Well water	3/71	–	4.4	–
Cistern water	3/71	65.9	15.2	116.5
Well water	7/71	–	–	–
Desalinized plant	7/71	–	–	–
Well water	8/71	–	–	–
Desalinized plant	8/71	–	–	–

TABLE 6—Average Pesticide Residues (ng/m^3) in Simultaneous Air Samples Taken in the Island and in Dade County, FL, 1970–1971

Location	No.	*p,p*-DDT	*o,p*-DDT	*p,p*-DDE	Dieldrin
Island	6	1.03	0.08	0.26	0.33
Dade County	6	1.96	0.73	0.75	0.86

men. The mean total DDT was 117 ppb in the males and 106 ppb in the females.

Table 3 compares serum organochlorine residues of the islanders with the black adult Dade County general population, Social Classes IV and V (Hollingshead Index).[8] Average resudies of DDT were 3 times higher on the island than on the mainland, and total DDT residues almost twice as high; the differences for all three residues were significant at the 0.001 level. In contrast, dieldrin levels were the same in both populations. The average age of the island group was 10 years older than that of the mainland residents but it is unlikely that these residue differences were due to age differences since age effects are unremarkable after 20 years of age.

The results of the questionnaire concerning domestic pesticide usage indicated that 71 per cent of persons used insecticides in the home for fly and roach control; 45 per cent of these respondents indicated that they had recently used a 5 per cent proprietary DDT solution in their homes. Additionally, a 5 per cent proprietary solution of DDT was observed in four of the six local stores visited at the time of the survey. In contrast, DDT has not been available for domestic pest control in Dade County for the last 2 years.*

Table 4 presents the pesticide residues obtained from analyses of the foods most commonly ingested by the residents. Residues of DDT and its metabolites, expressed in parts per million, were negligible. Table 5 presents the pesticide concentration (parts per trillion) in well water, cistern water, and water from the desalinization plant. DDT and its metabolites were not found except on one occasion. DDT, dieldrin, and lindane traces were found in one sample from the cistern and probably reflected incidental contamination since this was collected during a severe drought period.

Six simultaneous 24-hr air samples were collected over a 6-month period on the island and on the mainland. Average pesticide residue concentrations in nanograms per cubic meter are shown in Table 6. These concentrations of pesticides in air were also minimal and on all occasions were greater on the mainland than on the island.

Table 7 lists the individual pesticide concentrations of 15 paired interior and exterior soil and house dust samples from individual homes. One home was sampled three times and the results of these separate analyses are shown in Table 8. In this home the quantitative and qualitative characteristics of the pesticide residue spectrum in the

* Smith, J. L. President of Woodbury Chemical Company, Princeton, Florida, personal communication, April, 1972.

TABLE 7—Organochlorine Residues (ppm) in Paired Samples of Exterior Soils and Interior House Dusts from the Island, 1970–1971.

Initials and Sample No.	Site	DDT	DDE	DDD	Total DDT	Dieldrin	Methoxychlor	Endrin
NR 1	Interior	25.7	5.7	2.1	34.4	0.6	19.4	
	Exterior	7.2	4.3	0.25	12.2	0.1	3.5	
SS 2	Interior	463.8	13.8	6.1	486.0	4.5	212.8	<0.1
	Exterior	4.8	2.7	0.07	7.9	0.08	1.3	
AT 3	Interior	8.7	0.6	0.2	9.6	0.08	16.5	
	Exterior	4.0	1.9	0.1	6.2	0.03	0.9	
AR 4	Interior	33.3	3.0	5.1	42.3	0.7	10.0	
	Exterior	3.1	2.7	0.1	6.2	0.04	0.24	
EB 5	Interior	21.0	1.4	0.4	23.0	<0.004	31.7	
	Exterior	6.1	8.8	0.3	16.2	0.004	1.8	
SP 6	Interior	88.3	5.7	1.5	96.3	4.0	9.8	<0.02
	Exterior	1.6	1.6	0.1	3.5	0.1	–	
SL 7	Interior	41.9	3.1	4.1	49.9	29.3	10.4	0.8
	Exterior	3.0	0.9	0.6	4.7	0.1	0.8	
CD 8	Interior	75.1	4.5	1.4	81.7	1.7	2.1	
	Exterior	4.8	1.3	1.0	7.4	<0.004	–	
HS 9	Interior	13.4	1.4	0.3	15.3	0.09	0.7	
	Exterior	3.0	1.1	0.1	4.3	<0.1	0.1	
HF 10	Interior	21.7	2.9	1.5	26.6	0.63	5.1	
	Exterior	16.5	14.1	1.0	33.3	0.42	0.6	
RR 11	Interior	104.8	8.3	2.4	116.4	0.5	43.3	
	Exterior	2.9	3.2	0.04	6.5	0.01	–	
DR 12	Interior	5.8	0.8	0.3	7.0	–	22.6	
	Exterior	0.9	0.2	0.02	1.1	–	0.3	
JS 13	Interior	25.9	1.6	2.7	30.7	0.03	1.1	
	Exterior	2.9	1.0	0.3	4.3	0.1	–	
TD 14	Interior	908.0	3.0	5.0	916.9	0.5	117.0	
	Exterior	7.1	3.2	0.3	11.0	0.04	<0.02	
SM 15	Interior	0.7	0.3	0.08	1.1	<0.01	3.0	
	Exterior	1.2	0.6	0.03	1.8	0.02	<0.02	

TABLE 8—Comparison of Pesticide Residues (ppm) in Exterior and Interior House Dust from One Home (SS 2) on Three Separate Occasions, 1970–1971

Date Collected	Site	DDT	DDE	DDD	Total DDT	Dieldrin	Methoxychlor
10/4/70	Interior	546.2	15.6	6.2	570.5	6.2	198.0
	Exterior	9.1	5.1	0.1	14.9	0.2	3.0
1/14/71	Interior	376.6	12.9	5.9	397.5	4.4	166.9
	Exterior	4.0	1.9	0.12	6.2	0.03	0.9
7/21/71	Interior	468.6	12.9	6.4	490.1	3.0	273.5
	Exterior	1.3	1.3	<0.01	2.7	0.02	0.19

TABLE 9—Comparison of Organochlorine Residues (ppm) in Paired Samples of Exterior Soils and Interior House Dusts from the Island, 1970–1971

Type	No.	$\bar{x}$ DDT	$\bar{x}$ DDD	$\bar{x}$ DDE	$\bar{x}$ Total DDT	$\bar{x}$ Dieldrin	$\bar{x}$ Methoxychlor
Exterior soil	15	4.6	0.3	3.1	8.4	0.07	0.6
Interior house dust	15	122.5	2.2	3.7	129.1	2.84	33.7

house dust taken several months apart, and at different times of the year, was remarkably constant and shows that there is little change in the incidental exposure to this homeowner from this source. The data also show that the high concentrations of DDT noted in the first house dust were not due to the chance collection of a sample shortly after the house had been sprayed. The serum pesticide levels in the homeowner on September 19, 1970, taken 3 weeks before the first dust was collected from his home, was DDT 36 ppb, DDE 53 ppb, total DDT 94 ppb, and dieldrin 3 ppb. Fourteen months later his serum DDT was 27 ppb, DDE 67 ppb, total DDT 98.6, and dieldrin 1.6 ppb.

Table 9 compares the average exterior soil pesticide residue concentration with the average interior house dust concentrations. The average total DDT concentrations from the 15 sampling sites were 8.4 ppm outside the home and 129.1 ppm inside the home.

Taken collectively these several environmental residue surveys substantiated the data obtained from the questionnaire which indicated significant domestic usage of insecticide with 5 per cent DDT being used predominantly. They also support the concept that the increased human serum residues of DDT noted in this island community were the result of incidental domestic exposure to the 5 per cent DDT sollution applied in the home and human DDT pollution came mainly from house dust contamination. Using an Anderson Mini-Sampler residues of DDT were found in suspended particlate collected from ambient air 30 min after sweeping. Trace amounts were detected after passage through a sieve permitting droplet nuclei of 0.3-μ size; this is well below the respirable size.

The results of the physical examinations and biochemical tests in the health survey were unremarkable and in no way suggested that this degree of incidental exposure had any adverse health effects as measured by the tests used in the survey of the island population.

Conclusion and Summary

The island study indicated that the domestic use of DDT and its contamination of house dust was the major determinant of the body residues in the islanders in this tropical setting. In the past, primarily on the basis of pesticide residue studies in food, food has been presumed to be the major source of this pesticide in man in the U.S.[9] These data show that this is not always the case and illustrate the need for greater emphasis on nondietary sources in warmer climates. If in the future we continue to measure intake and storage of these pesticides, man and his microenvironment as well as food must surely be included in environmental monitoring programs.

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